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ECONOMIC RESEARCH SERVICE U.S. DEPARTMENT OF AGRICULTURE

WHEAT—REGIONAL SUPPLY ANALYSIS

by

Robert G. Hoffman*

ABSTRACT: A wheat supply model based on regional planted and harvested acreage equations represents Part I of a two part wheat econometric framework being developed to measure the factors affecting wheat production and price (demand) levels. The major characteristics of several types of wheat acreage adjustment programs in recent years have been quantified into two broad acreage policy measures—an "effective support rate", and an "effective voluntary diversion rate". These variables along with several other economic and weather condition variables have been used to develop planted and harvested acreage equations based on the 1950 to 1970 period. The policy variables differ somewhat with respect to their impact on wheat acres planted among the major wheat growing areas, but are generally important factors affecting planted and harvested acres. Wheat market price expectations represented by the U.S. prices received by farmers the previous year also are important factors affecting wheat acres.

KEY WORDS: Wheat, supply function, agricultural policies, acreage adjustments, acreage allotments, acreage diversions.

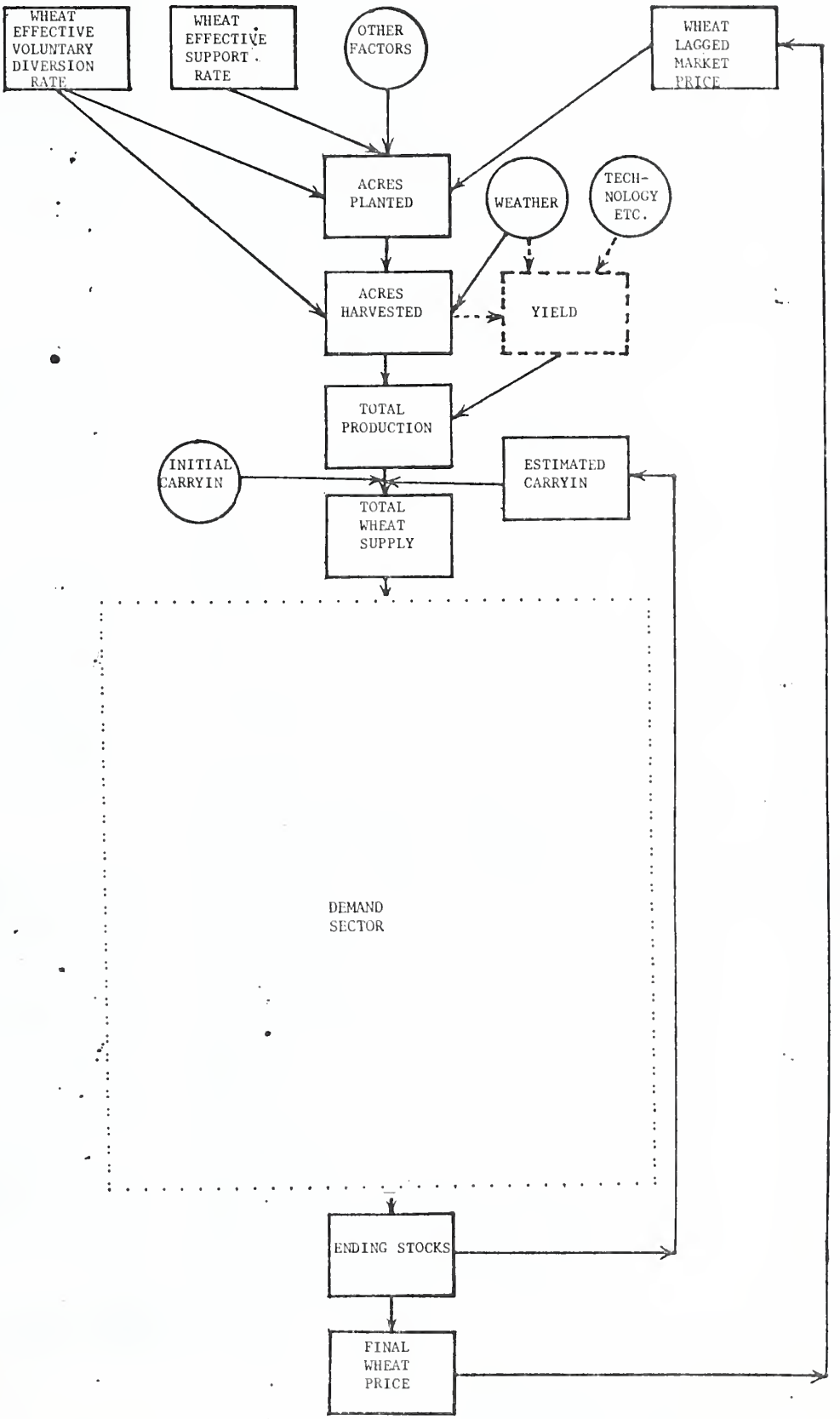
Formulation of an economic framework for determining probable price, use, and supply adjustments in the U.S. wheat economy—a framework nearly developed—has been complicated by several factors related to both the demand and supply aspects of the industry. Acreage programs have operated with a variety of specifications affecting supply adjustments. Wheat prices are generally acknowledged to be highly responsive to changes in quantities demanded for food, feed, and exports, but not until stocks are drawn down to relatively low levels.

The time series supply analysis presented here quantifies important acreage program adjustments factors, and along with other selected variables generates estimates of planted and harvested acres. A resulting wheat production estimate is then linked to the demand sector where quantities demanded and wheat prices are determined. the wheat price and estimated ending stocks are then in turn linked to the supply and demand solution for the following year.[1]

*The author is indebted to several members of the Economic Research Service, especially Jim L. Matthews, James J. Naive, and Frank R. Gomme for helpful suggestions in developing this paper. The responsibility for the analysis and its interpretation rests with the author. The author is an agricultural economists, National Economic Analysis Division, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

[1]This article represents Part I of a two part analytic economic analysis of the U.S. wheat situation. Part II, being developed by Terry N. Barr, Agricultural Economist, National Economic Analysis Division, ERS, covers an analysis of the major wheat demand relationships, and will appear in a future issue of the *Wheat Situation*. A statistical appendix containing data used in the supply analysis is available.

FIGURE 1
SCHEMATIC DIAGRAM OF WHEAT
SUPPLY-DEMAND SIMULATION MODEL



Wheat Program Review

Wheat annually accounts for about 55-60 million acres planted—nearly one-fifth of the total cropland planted in the United States. Although about 75 percent of the wheat production is in the Plains region, important acreages appear in nearly every State. Major influences on wheat acres in recent history have been government programs to maintain income to the wheat production economy while adjusting supplies. Programs have been in effect for decades, but are generally of two basic types which require wheat producers to make some degree of production adjustment in order to qualify for program payments and loan rates:

(1) 1939 to 1963

Allotments and relatively high loan rates (near parity), with associated penalties for exceeding established marketing quotas, were in effect for most of the 1939-63 period. Although allotments were not in effect, loan levels were maintained in some years of World War II and the Korean War.

(2) 1964 to present

In 1963, marketing quota penalities were eliminated, and wheat programs became voluntary. Loan levels dropped to the relatively low level of about 50 percent of parity. Since then, gross income to the wheat production sector has been maintained by a variety of direct payments—primarily the domestic marketing certificate. During this period (except 1964) the loan has been set at $1.25 per bushel.

Time series supply response analysis of wheat program effects can be limited to the total allotment level and the basic loan levels (1, 7, 8).[2] While planted acres of wheat are related to allotment levels, year to year changes may also be influenced by producer expected total returns as expressed by payment levels in combination with loan rates. Such a combined or "effective price support level" is an attempt to link the common major characteristics of each year's program into a consistent time series, and to relate changes in this variable along with other factors to changes in wheat acres planted by region.

Over the past two decades, the following common provisions have been directly related to acreage adjustments, although specific details have varied from year to year.

[2]Numbers in parentheses refer to references listed at the end of this report.

(1) Allotments
  (a) Total
and/or
  (b) Domestic
(2) Required diversion to meet:
  (a) Allotment provisions
  (b) Conserving use program provisions
(3) Cross-planting provisions
(4) Additional voluntary conserving use diversion

These program provisions form the basis of most of the annual wheat programs, although the language used to describe the provisions may differ somewhat from year to year. All the acreage provisions noted above, and any associated support rates have been in effect at one time or other since 1950—the period of analysis.

Wheat acreage program diversion characteristics, 1950-73[1]

	Provision in effect:			
	Required diversion		Addition voluntary diversion permitted	No diversion provisions
	To meet allotment provisions	To conserving use		
1950	×			
1951-53 . .				×
1954-55 . .	×			
1956-58 . .	×		×	
1959-61 . .	×			
1962-66 . .	×	×		
1967-68 . .	×			
1969-70 . .	×	×	×	
1971		×		
1972-73 . .		×	×	

[1] In several years, programs were announced or revised after winter wheat had been planted.

Allotment acres (total) are defined as acres permitted on individual farms. Producers meet a production restriction by planting within the allotment and thereby "diverting" wheat land from an historic base in order to qualify for guaranteed loans, payments, etc. This required acreage diverted (2a above) could be left idle, or in the more humid areas planted to some other crop. An additional form of required diversion (2b above) in recent years limits use of land strictly to conserving use, and could not be used for alternative major crops. A domestic allotment (roughly the acreage required to meet domestic requirements) was included in the total allotment for many years, but only under the recent set-aside programs has it been the sole allotment base for adjusting acreage.[3]

In several annual programs, participating producers could also voluntarily divert additional wheat land in return for specified compensation. This diversion provided an additional influence on the wheat acreage planted and harvested.

[3]Agricultural Act of 1970.

The Supply Model

The wheat supply model consists of regional planted and harvested functions with yield per harvested acre currently entered as predetermined.[4] Regions were chosen to generally represent wheat production areas by major class (4). Total U.S. spring wheat (both durum and other spring) acreage was included in the Northern Plains region, along with the winter wheat acreage in the 4 States (see table for States included in each region).

Planted Acres

Acreage planted relationships by region are based on linear relationships expressed as:

PLW(j) = f(PWH-1;Pi-1; ESW(j); EVD(j); RNC; CRA(j)
where
PLW(j) = acres planted, by region
PWH-1 = price of wheat, previous year
Pi-1 = price of competing crops, previous year
ESW(j) = effective support rate, by region
EVD(j) = effective voluntary diversion rate, by region
RNC = range (moisture) condition
CRA(j) = long term diverted acres, by region

Harvested Acres

Regional linear relationships were also used to describe regional wheat harvested acres as:

HRW(j) = f(PLW(j); EVD(j); WC(j)
where
HRW(j) = acres harvested, by region
PLW(j) = acres planted, by region
EVD(j) = effective voluntary diversion rate, by region
WC(j) = planted/harvested derived weather condition

[4]Preliminary analyses where yields are a function of (1) the harvested to base acres ratio; (2) fertilizer prices; (3) the derived weather condition; and (4) time trend, appear to be promising. For example, a current specification for the Southern Plains yield is:

HRYSP =	14.32 -	16.52 HR/B +	0.34WC -	10.33PF-1 +	.26T
(t)		(2.0)	(4.4)	(2.4)	(1.7)
"e"		-.5	1.6	-1.5	.7

R^2 = .84

HRYSP = wheat yield per harvested acre, Southern Plains, bu./ac.
HR/B = wheat harvested acres divided by base acres, Southern Plains, ratio
WC = derived weather condition, Southern Plains, 100=base
PF = weighted wheat fertilizer ingredient cost previous year, cent/lb.
T = technology time trend, 1960=60.

Factors Affecting Wheat Planting

Regional supply response for wheat is postulated to be largely determined by an "effective" support rate, effective voluntary diversion payments, and expectation of market prices represented by the previous year's price. previous year's price.

Effective Loan Rate

The effective loan rate concept is based on a guaranteed gross return on the acreage planted and diverted within the program provisions (6). Since a grower must comply with specified acreage restrictions in order to receive the announced loan guarantee plus any direct income payments, the total support is factored into an effective support rate by the percentage of allowed acreage relative to some possible desired or "planting potential" acreage. Desired acreage is not a directly observable variable and is approximated by using the 1951 to 1953 average plantings as an historic base acreage. During this period there were no allotments, prices were relatively high and plantings large. It represents a peak for potential planted area. Such a base is somewhat arbitrary and can be adjusted to long term structural changes. Thus, the effective loan can be altered by changing allotments, mandatory diversion, the announced loan rate, any associated direct payments, or the base itself. For example, if only an allotment is in effect, the ratio of allotment acres to base acres is employed to adjust the basic loan rate, assume:

I. Example 1.

Allotment = 50 million acres
Base = 70 million acres
Ratio = 50/70 = 0.714
Loan = $2.00 per bushel on total allotted acres
Effective support rate = (0.714 x $2.00) = $1.43 per bushel

Additional adjustments (required diversion payments; price support payments, etc.) may be factored in as well. For instance, assume:

II. Example 2.

Allotment = 50 million acres
Base = 70 million acres
Ratio = 50/70 = 0.714
Loan = $1.25 per bushel on total allotted acres (or base acres adjusted for set aside)
Domestic Certificate = $1.50 per bushel on domestic allotment acres of 15 million
Ratio = 15/70 = 0.214
Effective support rate = (0.714 x $1.25) + (0.214 x $1.50) = $1.21 per bushel

Lower loan rates since 1963 have been offset by higher diversion payments to maintain producer incomes while permitting the price structure for wheat to fall to levels more in line with world prices. Such "trade-offs" between loan rates and direct payments result in small changes in the computed effective loan rate.

Adjustments in total wheat production is typically obtained by altering acreage restrictions. For example, 1965's provision of the wheat and feed grain program permitted wheat to be substituted on feed grain base acres and feed grain on wheat acres. This "cross-planting" provision gave wheat producers the opportunity to offset any required diversion in the wheat program with feed grain base acres if available. It also effectively reduced the total required diversion for wheat and therefore increased the effective support rate. This type of program change had a generally positive impact on wheat acres planted. More wheat was planted on feed grain acres (primarily barley) than feed grains planted on wheat acres.

Effective Voluntary Diversion

Additional voluntary diversion to conserving use has been an important adjustment factor in some years. Since producers can voluntarily divert acreage only after they meet the program requirements, the voluntary diversion provisions are considered as a separate factor with an expected negative effect on acreage. The calculation of this variable is similar to the effective loan rate since the voluntary diversion payment rate is adjusted by the ratio of permitted acres to the historic base.

Market Price Expectations

Market prices for wheat and competing crops should importantly influence plantings. Even though marketing quotas and associated penalties were in effect for much of the 1950 to 1963 period, producers could overplant their allotment. Such plantings over allotment averaged about 5 million acres annually.

Since 1964, wheat program benefits have been largely based on the domestic allotment with no penalities. Additional plantings beyond the domestic allotment would also be expected to be influenced by market price and production cost considerations. With the introduction of cross-planting provisions in 1965 and the set-aside program of 1970, market prices would be expected to be even more important in planting decisions.

Other Factors

Soil moisture conditions in the Plains also affect acreage planted. An aggregate measure or moisture proxy for the Plains is represented by the October 1 range condition statistic for the Western States reported by the Statistical Reporting Service. Favorable range (moisture) conditions and plantings would be expected to be positively related.

Long-term acreage diversion programs may also influence planted wheat acres. The most important such program (Conservation Reserve) accounted for a peak of nearly 29 million acres in 1960-61—although not all of this acreage was originally in wheat production.

Factors Affecting Wheat Harvested

Wheat harvested acres would of course be largely determined by the planted acres. However the ratio of harvested to planted acres would be expected to vary by region. In addition, the effective voluntary diversion rate would also influence the ratio of harvested to planted acres. Weather factors affecting the winterkill and/or germination of wheat should also play an important role in affecting changes in wheat acres harvested, once the wheat has been planted.

Summary of regional wheat supply elasticities

Region	Effective support rate		Wheat price previous year	
	Elasticity at mean	Effect of 10 cent increase	Elasticity at mean	Effect of 10 cent increase
	Million acres	*Million acres*	*Million acres*	*Million acres*
Southern Plains	0.50	1.0	0.42	0.7
Northern Plains	.39	.5	.43	.4
Northwest	.08	---	n.a.	---
Cornbelt	.14	.1	.84	.4
Other States	.01	(1)	.41	(1)

n.a. = not available.
[1] Less than 0.05.

Statistical Results and Implications

The effective support rate significantly describes changes in wheat acres planted in the leading wheat production regions (Southern and Northern Plains). However, the rate appears to have little statistically significant impact in the remaining regions. The implied elasticity in the Southern Plains suggests that a 10 cent per bushel increase in the effective support rate for wheat is associated with about a 1 million acre increase in wheat plantings.

The effective voluntary diversion rate has much less of an impact than the effective support rate. However, its relative influence, as measured by the elasticity, is about the same in each region.

The market price expectation, as defined by the lagged U.S. price received by farmers for wheat, is an important explanatory variable in each region except the Northwest and "Other" Region. The results suggest that the annual program specification along with market price expectations explain most of the annual variation in wheat acres planted. The supply response with respect to the lagged price is relatively inelastic in the Northern and Southern Plains ranging from 0.40 to 0.45. A 10 cent increase in lagged market price is assoicated with about a three-quarter-million acre increase in wheat planted in the Southern Plains, and nearly a half-million acres in the Northern Plains. The price response is greatest in the Corn Belt where the program provisions (effective support rate) appear to have little impact.[5] (see table, Summary of regional wheat planted equations).

Regional wheat harvested acreage functions relate the acres harvested to planted acres, the effective voluntary diversion rate, and a derived weather condition variable based on residuals (see table Summary of regional wheat harvested equations)[6] Changes in planted acres obviously describe most of the changes in harvested acres. But the effective voluntary diversion rate also appears to be statistically significant in affecting harvested acres, although its impact is somewhat less than on planted acres. Decisions on voluntary diversion could be made at program sign-up time after an assessment of crop condition at that time (generally February and March).

[5] For part of the past 2 decades (1956-64) producers were permitted to exceed their allotment but at the same time not exceed 15 acres. These acres "in excess of allotment but not subject to penalty" were mostly in the North Central (Corn Belt) States where individual farm allotments were much smaller than in the major producing areas and mostly below 15 acres. Presumably these producers would therefore be much more responsive to price than to the wheat program.

[6] An initial set of equations was fitted with harvested acres as a function of planted acres and the effective voluntary diversion rate. The residual of these equations expressed as indices was assumed to primarily represent the "weather" effect for each region.

The supply model results suggest that certain key characteristics pervade the annual wheat programs since at least the early 1950's. These characteristics or provisions can be related to a time series analysis to derive estimated impacts on wheat acreage. Annual adjustments are directly related to changes in the announced wheat program as well as producers' expectations of market prices with little carryover effect from programs and price of past years. The program variables not only directly affect planted acres, but also the ratio of harvested to planted acres through the voluntary diversion payment provision.

Actual and Estimated Values—Recent Years

In recent years, the combined regional estimates of plantings is above the actual level. However, each year's direction of change is correctly picked up by the estimating equations. Since actual plantings were 2 to 4 million acres less than estimated, programs in recent years may have been somewhat more restrictive than indicated by the program variables. In addition, the timing of program announcements has left room for interpreting which program variables affect each crop. In cases where program provisions were announced after the winter wheat was planted, the provision of the previous year was assumed to be still relevant. The unusual effects of the wet fall weather in 1972 primarily in the Corn Belt and Other Region, which limited plantings, were not taken into account for the 1973 estimates of plantings.

Applications for 1973 and 1974

An application of the plantings equations is demonstrated in the following table. Here the 1972 to 1973 changes in the variable values are multiplied by their respective coefficients to derive the indicated individual effect of each of the major factors. For example in the Southern Plains, the effective support rate, and effective voluntary diversion tended to reduce wheat acres in that region. But substantially higher wheat prices for the 1972/73 marketing years,—more than offset the decline. However, the increase in estimated acres was somewhat larger than actual acres mostly because of a overestimate in the Cornbelt region.

The high wheat prices forecast for the 1973/74 marketing season suggests a continued significant impact on wheat acres planted for 1974 harvest from market prices alone. However, other factors such as prices of competing crops, as well as moisture conditions, could well dampen the impact from wheat prices alone. An increase for wheat from $1.80 per bushel in 1972/73 would indicate another 8 to 10

Summary of regional wheat plantings equations

Dependent variable PLW(j)	ESW(j)	EVD(j)	PWH-1	PCOT-1	PLW(j)$_{-1}$	RNC	CRA(j)	K	R^2	D.W.	s.e.	σ
Region												
Southern Plains	8.9623	-5.8382	6.6946	-23.9785		0.2881	-0.1097	-11.6205	0.82	1.61	2.19	4.36
(t)	(3.3)	(2.7)	(2.2)	(1.2)		(2.5)	(.5)					
"e"	.50	-.07	.42	-.25		.80	-.01					
Northern Plains	4.8614	-2.3227	4.1476			.1572	-.4957	-7.6373	.83	1.88	1.68	3.49
(t)	(3.2)	(1.3)	(2.7)			(1.8)	(2.8)					
"e"	.39	-.05	.43			.72	-.07					
Northwest	.2321	-.3956			0.4578		-.1948	2.2048	.60	1.44	.45	.66
(t)	(.4)	(1.0)			(1.7)		(.6)					
"e"	.08	-.04			.46		-.02					
Corn Belt	.6489	-1.2090	3.9983				-.0759	.4452	.71	1.14	.93	1.56
(t)	(.5)	(1.3)	(4.9)				(.5)					
"e"	.14	-.05	.84				-.02					
Other	.0173	-.3107	.4415	-4.9410			-.0345	2.6954	.24	1.67	.38	.37
(t)	(.04)	(.8)	(.8)	(1.6)			(.5)					
"e"	.01	-.01	.41	-.80			-.03					

(t) = t value. e = Elasticity at the mean.

D.W. = Durbin-Watson statistic
s.e. = Standard error
σ = Standard deviation
PLW(j) = Wheat acres planted, by region, million acres
ESW(j) = Wheat effective support rate, by region, $/bu.
EVD(j) = Wheat effective voluntary diversion rate, by region, $/bu.
PHW-1 = Prices received by farmers for wheat, season average, previous year, $/bu.
PCOT-1 = Prices received by farmers for cotton, season average, previous year, ¢/lb.
RNC = Range condition, October 1, Western States, 100 = normal.
CRA(j) = Conservation reserve acres under contract, by region, million acres.

Southern Plains = winter wheat in Nebraska, Kansas, Oklahoma, Texas, New Mexico, Colorado, and Wyoming.
Northern Plains = durum and other spring wheat (U.S.) and winter wheat in North Dakota, South Dakota, Montana and Minnesota.
Northwest = winter wheat in Washington, Oregon, Idaho, Utah, Nevada, California, and Arizona.
Corn Belt = winter wheat in Ohio, Indiana, Illinois, Michigan, Wisconsin, Iowa, Missouri, Pennsylvania, Maryland, New Jersey, and 7 other Northeastern States.
Other = Arkansas, Louisiana, Mississippi, Virginia, North Carolina, South Carolina, and 6 other Southeastern States.

Regional wheat harvested equations

Dependent variable HRW(j)	PLW(j)	EVD(j)	WC(j)	K	R^2	D.W.
Southern Plains	0.5247	-1.2237	0.2314	-14,6088	0.989	2.83
(t)	(18.6)	(5.9)	(21.3)			
"e"	.63	-.02	1.02			
Northern Plains	.9304	-.4967	.1565	-15.2644	.999	1.74
(t)	(113.2)	(8.5)	(22.2)			
"e"	.99	-.01	1.01			
Northwest	.9424	-.0113	.0381	-3.8953	.999	2.39
(t)	(104.5)	(1.1)	(25.3)			
"e"	1.02	---	.93			
Corn Belt	.9763	-.0338	.0743	-7.7081	.995	1.90
(t)	(175.71)	(2.0)	(20.4)			
"e"	1.03	---	.96			
Other States	.9020	-.0120	.0107	-1.2002	.995	1.35
(t)	(53.2)	(.9)	(2.5)			
"e"	1.08	---	.68			

(t) = t value
"e" = elasticity at the mean
D.W. = Durbin Watson statistic
HRW(j) = Wheat acres harvested, by region, million acres
PLW(j) = Wheat acres planted, by region, million acres
EVD(j) = Effective voluntary diversion rate, by region, $/bu.
WC(j) = Planted/harvested weather condition factor.

Wheat acres planted: Summary of model estimates and actual acres

Year	Southern Plains		Northern Plains		Northwest		Corn Belt		Other		United States	
	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.
	Million acres	*Million acres*	*Million acres*	*Million acres*	*Million acres*	*Million acres*	*Million acres*	*Million acres*	*Million acres*	*Million acres*	*Million acres*	*Million acres*
1969	27.9	26.4	15.5	14.6	5.0	5.0	6.2	5.8	2.1	1.7	56.7	53.4
1970	24.9	23.8	14.8	13.5	4.8	4.8	6.3	4.9	2.2	1.8	53.0	48.7
1971	24.3	23.6	17.9	18.4	4.8	4.8	6.5	4.8	2.2	2.2	55.7	53.8
1972	26.4	25.9	16.8	15.7	4.8	5.3	6.8	5.6	1.9	2.4	56.7	54.9
1973	28.4	27.4	19.3	18.7	4.9	5.8	8.1	5.1	2.1	1.8	62.8	58.8

million acre increase in wheat planted this fall. Nearly one-half of such an increase would probably occur in the Southern Plains. However, if the Corn Belt retains its historic responsiveness to market price changes and weather is normal this fall, a sharp increase in acres (1.5 to 2 million) may be possible in this region alone. Planting decisions are not yet formulated, and the combined effects of the remaining factors, especially weather and moisture conditions, cannot yet be determined.

Indicated effect of major factors on regional wheat acres planted, 1972 to 1973 change

Region	Effective support rate	Effective voluntary diversion	Wheat price previous year	Remaining factors	1972 to 1973 change	
					Combined estimated	Actual
	Million acres	*Million acres*	*Million acres*	*Million acres*	*Million acres*	*Million acres*
Southern Plains	-0.5	-1.9	3.0	1.5	2.1	1.5
Northern Plains	-.1	.4	1.8	.4	2.5	3.0
Northwest	---	-.1	---	.2	.1	.5
Corn Belt	---	-.5	1.7	---	1.2	-.5
Other	---	---	.2	—	.2	-.6
United States	-.6	-2.1	6.7	2.1	6.1	3.9

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